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First Named Inventor	Hironori Kakiuchi
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Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	Seed Intellectual Property Law Group PLLC	Customer Number 00500	
Signature	Raymond W Armentrout		
Printed Name	Raymond W. Armentrout		
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DECLARATION

I, Koichi OISHI Patent Attorney, of OISHI & PARTNERS, 4th Floor, Kanda-ON Building, 1-10, Kandasudacho, Chiyoda-ku, Tokyo 101-0041 Japan, hereby certify that I am the translator of the certified official copy of the documents in respect of an application for a Patent filed in Japan on January 28, 2003 under Patent Application No. 2003-19170 and that the following is a true and correct translation to the best of my knowledge and belief.

Koichi OISHI
Patent Attorney

Dated: May 7, 2007

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[Inventor]	
[Address]	TDK Corporation, 1-13-1, Nihonbashi, Chuo-ku, Tokyo, JAPAN
[Name]	Hironori KAKIUCHI
[Inventor]	
[Address]	TDK Corporation, 1-13-1, Nihonbashi, Chuo-ku, Tokyo, JAPAN
[Name]	Hiroyasu INOUE
[Applicant(s)]	
[Discrimination Number]	000003067
[Name]	TDK CORPORATION
[Attorney]	
[Discrimination Number]	100078031
[Patent Attorney]	
[Name]	Koichi OISHI
[Designated Attorney]	
[Discrimination Number]	100115738
[Patent Attorney]	
[Name]	Mitsuhiro WASHIZU
[Designated Attorney]	
[Discrimination Number]	501481791

[Patent Attorney]		
[Name]	Kazufumi OGATA	
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[TITLE OF THE INVENTION]

OPTICAL RECORDING MEDIUM

[CLAIMS]

[Claim 1] An optical recording medium comprising a substrate and a recording layer which is formed over the substrate and in which a recording mark can be formed by projecting a laser beam thereonto, the recording layer comprising a first reaction layer formed of a material containing copper (Cu) as a primary component and 10 atomic % to 30 atomic % of aluminum (Al) as an additive and a second reaction layer formed of a material containing an element selected from the group consisting of silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) and aluminum (Al) as a primary component.

[Claim 2] An optical recording medium in accordance with Claim 1, which further comprises a first dielectric layer and a second dielectric layer on the both sides of the recording layer.

[Claim 3] An optical recording medium in accordance with Claim 1 or 2, which further comprises a light transmission layer having a thickness of 10 to 300 µm on the opposite side to the substrate with respect to the recording layer.

[Claim 4] An optical recording medium in accordance with any one of Claims 1 to 3, wherein the laser beam has a wavelength of 380 nm to 450 nm.

[Claim 5] An optical recording medium comprising a substrate and a plurality of information record layers formed over the substrate, a recording layer included in a predetermined information recording layer other than a information recording layer farthest from a light incidence plane through which a laser beam enters comprising a first reaction layer formed of a material containing copper (Cu) as a primary component and 10 atomic % to 30 atomic % of aluminum (Al) as an additive and a second reaction layer formed of a material containing an element selected from the group consisting of silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) and aluminum (Al) as a primary component.

[Claim 6] An optical recording medium in accordance with Claim 5, wherein the information record layers formed on the opposite side to the light incidence plane with respect to the predetermined information recording layer is constituted so that data can be recorded therein or reproduced therefrom by projecting a laser beam having a wavelength of 380 nm to 450 nm thereonto.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

The present invention relates to an optical recording medium and, particularly, to a write-once type optical recording medium.

[0002]

[DESCRIPTION OF THE PRIOR ART]

Optical recording media such as the CD, DVD and the like have

been widely used as recording media for recording digital data. These optical recording media can be roughly classified into optical recording media such as the CD-ROM and the DVD-ROM that do not enable writing and rewriting of data (ROM type optical recording media), optical recording media such as the CD-R and DVD-R that enable writing but not rewriting of data (write-once type optical recording media), and optical recording media such as the CD-RW and DVD-RW that enable rewriting of data (data rewritable type optical recording media).

[0003]

Data are generally recorded in a ROM type optical recording medium using prepits formed in a substrate in the manufacturing process thereof, while in a data rewritable type optical recording medium a phase change material is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by phase change of the phase change material.

[0004]

On the other hand, in a write-once type optical recording medium, an organic dye such as a cyanine dye, phthalocyanine dye or azo dye is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by chemical change of the organic dye, which change may be accompanied by physical deformation. Unlike data recorded in a data rewritable type optical recording medium, data recorded in a write-once type optical recording medium cannot be erased and rewritten. This means that data recorded in a write-once type optical recording medium cannot be falsified, so that the write-once type optical recording medium is useful in the case where it is necessary to prevent data recorded in an optical recording medium from being falsified.

[0005]

However, since an organic dye is degraded when exposed to sunlight or the like, it is difficult to improve long-time storage reliability in the case where an organic dye is used as the material of the recording layer. Therefore, it is desirable for improving long-time storage reliability of the write-once type optical recording medium to form the recording layer of a material other than an organic dye.

[0006]

As disclosed in Japanese Patent Application Laid Open No. 62-204442, there is known an optical recording material whose recording layer is formed by laminating two reaction layers each containing an inorganic material is known as an example of an optical recording medium whose recording layer is formed of a material other than an organic dye.

[0007]

[Patent Publication 1]

Japanese Patent Application Laid Open No. 62-204442

[PROBLEMS TO BE SOLVED BY THE INVENTION]

However, in the write-once type optical recording medium disclosed in Patent Publication 1, it is difficult to store the initially recorded data in the recording layers in a good condition over the long term and since the surface smoothness of this optical recording medium is not necessarily good, the initial recording characteristic may be poor.

[0008]

In order to solve these problems, the applicant of this patent application has already proposed in Japanese Patent Application No. 2002-104317 a write-once type optical recording medium whose recording layer is constituted by laminating a first reaction layer formed of a

material containing an element selected from the group consisting of silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) and aluminum (Al) as a primary component and a second reaction layer formed of a material containing copper (Cu) as a primary component. It has been found that if a recording layer of a write-once type optical recording medium is formed in this manner, it is possible to store the initially recorded data with high sensitivity in the recording layers in a good condition over the long term.

[0009]

However, it has not yet become known what materials are suitable for forming the first reaction layer and the second reaction layer and what ratio of the materials contained in each of the first reaction layer and the second reaction layer should be determined in order to simultaneously improving the jitter characteristics of a reproduced signal and the recording sensitivity of the write-once type optical recording medium.

[0010]

It is therefore an object of the present invention to provide an optical recording medium whose recording layer is formed by laminating at least two reaction layers, in which the materials for forming the at least two reaction layers and the ratio of the materials contained in each of the at least two reaction layers are optimized and the jitter characteristics of a signal reproduced therefrom and the recording sensitivity thereof are simultaneously improved.

[0011]

[MEANS FOR SOLVING THE PROBLEMS]

An optical recording medium according to one preferred aspect of the present invention is characterized in that it comprises a substrate

and a recording layer which is formed over the substrate and in which a recording mark can be formed by projecting a laser beam thereonto and that the recording layer comprises a first reaction layer formed of a material containing copper (Cu) as a primary component and 10 atomic % to 30 atomic % of aluminum (Al) as an additive and a second reaction layer formed of a material containing an element selected from the group consisting of silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) and aluminum (Al) as a primary component.

[0012]

According to this preferred aspect of the present invention, it is possible to provide an optical recording medium which has a high storage reliability and is simultaneously improved in the jitter characteristics of a signal reproduced therefrom and the recording sensitivity thereof. In the present invention, it is preferable the amount of aluminum (Al) to be added to the first reaction layer to be 10 atomic % to 25 atomic %, it is more preferable for the amount of aluminum (Al) to be 20 atomic % to 25 atomic % and it is particularly preferable for the amount of aluminum (Al) to be about 20 atomic %.

[0013]

Further, in the present invention, it is preferable for the optical recording medium to further comprise a first dielectric layer and a second dielectric layer on the both sides of the recording layer. It is further preferable for the optical recording medium to further comprise a light transmission layer having a thickness of 10 to 300 μm on the opposite side to the substrate with respect to the recording layer. An optical recording medium having such a thin light transmission layer is a next-generation type optical recording medium. Furthermore, it is

preferable for a laser beam to have a wavelength of 380 nm to 450 nm. In the case where a laser beam having a wavelength of 380 nm to 450 nm is used for recording data in an optical recording medium, it is possible to obtain particularly high modulation

[0014]

An optical recording medium according to another preferred aspect of the present invention is characterized in that it comprises a substrate and a plurality of information record layers formed over the substrate, and that a recording layer included in a predetermined information recording layer other than a information recording layer farthest from a light incidence plane through which a laser beam enters comprises a first reaction layer formed of a material containing copper (Cu) as a primary component and 10 atomic % to 30 atomic % of aluminum (Al) as an additive and a second reaction layer formed of a material containing an element selected from the group consisting of silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) and aluminum (Al) as a primary component.

[0015]

According to this preferred aspect of the present invention, since the predetermined information recording layer has a light transmittance, it is possible to record data in or reproduce data from an information recording layer disposed on the opposite side to the light incidence plane with respect to the predetermined information recording layer without being affected by the present of the predetermined information recording layer in addition to the above described advantages.

[0016]

Further, in the present invention, it is preferable for an information recording layer disposed on the opposite side to the light

incidence plane with respect to the predetermined information recording layer to be constituted so that data can be recorded therein or data can be reproduced therefrom by projecting a laser beam having a wavelength of 380 nm to 450 nm. Since the difference in a light transmittance with respect to a laser beam having a wavelength of 380 nm to 450 nm between a region of the predetermined information recording layer where a recording mark is formed and other regions of the predetermined information recording layer is extremely small, it is possible to record data in or reproduce data from an information recording layer disposed on the opposite side to the light incidence plane with respect to the predetermined information recording layer in a stable manner.

[0017]

[DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Hereinafter, preferred embodiments of the present invention will now be explained with reference to accompanying drawings.

[0018]

Figure 1 (a) is a schematic partially cut-out perspective view showing an external appearance of an optical recording medium that is a preferred embodiment of the present invention and Figure 1 (b) is an enlarged schematic cross-sectional view of the part of the optical recording medium indicated by A in Figure 1 (a).

[0019]

As shown in Figures 1 (a) and (b), an optical recording medium 10 according to this embodiment is formed disk-like and has an outer diameter of about 120 mm and a thickness of about 1.2 mm. As shown in Figure 1 (b), the optical recording medium 10 includes a support substrate 11 and a reflective layer 12, dielectric layers 13 and 15, a recording layer 14 and a light transmission layer 16. The optical

recording medium 10 according to this embodiment is constituted as a write-once type optical recording medium so that data can be recorded therein and reproduced therefrom by projecting a laser beam L having a wavelength of 380 nm to 450 nm, preferably about 405 nm onto a light incidence plane constituted by the surface of the light transmission layer 16. When data are to be recorded in and reproduced from the optical recording medium 10, an objective lens having a numerical aperture equal to or larger than 0.7, preferably about 0.85 is used, whereby a spot diameter of the laser beam L is made to be about 0.4 μm on the surface of the recording layer 14.

[0020]

The support substrate 11 is a dick-like substrate serving as a support for ensuring a thickness of about 1.2 mm required for the optical recording medium 10 and having a thickness of about 1.1 mm. Grooves 11a and lands 11b are spirally formed on the surface of the support substrate 11 from a portion in the vicinity of the center of the support substrate 11 toward the outer peripheral portion thereof for guiding a laser beam L. Although not particularly limited, the depth of the groove 11a is preferably set to 10 nm to 40 nm and the pitch of the grooves 11a is preferably set to 0.2 μm to 0.4 μm. The material used to form the support substrate 11 is not particularly limited and the support substrate 11 can be formed of glass, ceramic, resin or the like. Among these, resin is preferably used for forming the support substrate 11 since resin can be easily shaped. Illustrative examples of resins suitable for forming the support substrate 11 include polycarbonate resin, polyolefin resin, acrylic resin, epoxy resin, polystyrene resin, polyethylene resin, polypropylene resin, silicone resin, fluoropolymers, acrylonitrile butadiene styrene resin, urethane resin and the like. Among these, polycarbonate resin and

polyolefin resin are most preferably used for forming the support substrate 11 from the viewpoint of easy processing and the like. In this embodiment, since the laser beam L is not projected onto the recording layer 14 via the support substrate 11, it is unnecessary for the support substrate 11 to have a high light transmittance property.

[0021]

It is preferable to fabricate the support substrate 11 by an injection molding process using a stamper but the support substrate 11 may be fabricated using another process such as a 2P process.

[0022]

The reflective layer 12 serves to reflect the laser beam L entering through the light transmission layer 16 so as to emit it from the light transmission layer 16. The material used for forming the reflective layer 12 is not particularly limited insofar as it can reflect a laser beam L. Illustrative examples of the materials used for forming the reflective layer 12 include magnesium (Mg), aluminum (Al), titanium (Ti), chromium (Cr), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), germanium (Ge), silver (Ag), platinum (Pt), gold (Au) and the like. Among these materials, it is preferable to form the reflective layer 12 using a metal material such as aluminum (Al), gold (Au), silver (Ag), copper (Cu) and an alloy containing one or more these metal such as an alloy of Al and Ti from the viewpoint of reflection. It is not absolutely necessary to provide a reflective layer 12 in the present invention but it is preferable to provide the reflective layer 12 in order to obtain a higher reproduced signal (C/N ratio) by a multiple interference effect. Further, it is possible to interpose a moisture proof layer consisting of a dielectric material between the support substrate 11 and the reflective layer 12 for preventing the reflective layer 12 from being corroded.

[0023]

It is preferable to form the reflective layer 12 to have a thickness of 5 to 300 nm and is more preferable to form it to have a thickness of 20 to 200 nm. In the case where the thickness of the reflective layer 12 is thinner than 5 nm, the above described advantages cannot sufficiently be obtained. On the other hand, in the case where the thickness of the reflective layer 12 exceeds 300 nm, the surface smoothness of the reflective layer 12 is degraded and it takes a longer time for forming the reflective layer 12, thereby lowering the productivity of the optical recording medium 10. To the contrary, in the case where the thickness of the reflective layer 12 is set to 5 to 300 nm, in particular, in the case where the thickness of the reflective layer 12 is set to 20 to 200 nm, the above described advantages can be obtained and it is possible to improve the surface smoothness of the reflective layer 12 and prevent the productivity of the optical recording medium 10 from being lowered.

[0024]

The dielectric layers 13 and 15 serve to physically and chemically protect the recording layer 14 and it is possible to effectively prevent data recorded in the recording layer 14 from being degraded for a long time by sandwiching the recording layer 14 by the dielectric layers 13 and 15.

[0025]

The material usable for forming the dielectric layers 13 and 15 is not particularly limited insofar as it is transparent with respect to the laser beam L and the dielectric layers 13 and 15 can be formed of a dielectric material containing oxide, sulfide, nitride or a combination thereof, for example, as a primary component. In order to prevent the support substrate 11 from being deformed by heat and improve the

characteristics of the dielectric layers 13 and 15 for protecting the recording layer 14, it is preferable to form the dielectric layers 13 and 15 of an oxide, sulfide, nitride or carbide of aluminum (Al), silicon (Si), cerium (Ce), titanium (Ti), zinc (Zn), tantalum (Ta) or the like, such as Al_2O_3, AlN, ZnO, ZnS, GeN, GeCrN, CeO_2, SiO, SiO_2, Si_3N_4, SiC, La_2O_3, TaO, TiO_2, SiAlON (mixture of SiO_2, Al_2O_3, Si_3N_4 and AlN), LaSiON (mixture of La_2O_3, SiO_2 and Si_3N_4) or the like, or the mixture thereof, and it is particularly preferable to form the dielectric layers 13 and 15 of a mixture of ZnS and SiO_2. In the case where the dielectric layers 13 and 15 are formed of the mixture of ZnS and SiO_2, the mole ratio of ZnS to SiO_2 is preferably 80:20. The dielectric layers 13 and 15 may be formed of the same dielectric material or of different dielectric materials. Moreover, at least onand the second dielectric layer 13 may have a multi-layered structure including a plurality of dielectric films.

[0026]

The thickness of each of the dielectric layers 13 and 15 is not particularly limited but each of the dielectric layers 13 and 15 is preferably formed to have a thickness of 3 nm to 200 nm. In the case where the thickness of each of the dielectric layers 13 and 15 is thinner than 3 nm, it becomes difficult to obtain the above described advantages. On the other hand, in the case where the thickness of each of the dielectric layers 13 and 15 is thicker than 200 nm, it takes a long time to form the dielectric layers 13 and 15, thereby lowering the productivity of the optical recording medium 10, and cracks may be generated in the optical recording medium 10 owing to stress present in the dielectric layers 13 and/or 15.

[0027]

The dielectric layers 13 and 15 also serve to increase the

difference in optical properties of the optical recording medium 10 between before and after data recording and it is therefore preferable to form the dielectric layers 13 and 15 of a material having a high refractive index *n* in the wavelength range of the laser beam L. Further, since the recording sensitivity becomes low as the energy absorbed in the dielectric layers 13 and 15 becomes large when the laser beam L is projected onto the optical recording medium 10 and data are to be recorded therein, it is preferable to form the dielectric layers 13 and 15 of a material having a low extinction coefficient *k* in the wavelength range of the laser beam L.

[0028]

The recording layer 14 is a layer in which an irreversible recording mark is to be formed and is constituted by laminating a plurality of reaction layers. As shown in Figure 2 (a), the reaction layer 21 and the reaction layer 22 are laminated at an unrecorded region of the recording layer 14. When the recording layer 14 is irradiated with a laser beam having a predetermined power or more, the element contained in the reaction layer 21 as a primary component and the element contained in the reaction layer 22 as a primary component partially or totally diffuse by heat generated by the laser beam to mix with each other, whereby a recording mark M is formed, as shown in Figure 2 (b). As a result, since the reflection coefficient of a mixed region of the recording layer 14 where the recording mark M is formed and that of other regions of the recording layer 14 with respect to a laser bream are greatly different from each other, data can be recorded in and reproduced from the optical recording medium 10 utilizing the difference in reflection coefficient therebetween. Data recorded in the optical recording medium 10 can be expressed by the length of the recording mark M, namely, the length between the front edge portion of the recording mark M and the

rear edge portion thereof, and the length of the blank region, namely, the length between the rear edge portion of the recording mark M and the front edge portion of a next recording mark M. Each of lengths of a recording mark M and a blank region is set as integral multiple of T where T is a length corresponding to that of one cycle of a reference clock and concretely, a recording mark and a blank region having each of 2T to 8T are used in the 1.7RLL Modulation Code.

[0029]

In the present invention, one of the reaction layer 21 and the reaction layer 22, preferably, the reaction layer 21, is formed of a material containing copper (Cu) as a primary component and 10 atomic % to 30 atomic % of aluminum (Al) as an additive. In the case where the amount of aluminum (Al) contained in one of the reaction layer 21 and the reaction layer 22 is less than 10 atomic % or exceeds 30 atomic %, jitter of a signal obtained by reproducing a recording signal becomes high and in the case where the amount of aluminum (Al) contained in one of the reaction layer 21 and the reaction layer 22 is less than 10 atomic %, the storage reliability of an optical recording medium 10 becomes insufficient. To the contrary, in the case where the amount of aluminum (Al) contained in one of the reaction layer 21 and the reaction layer 22 is equal to or smaller than 25 atomic %, the recording sensitivity of an optical recording medium 10 becomes high. Therefore, it is preferable to add 10 atomic % to 25 atomic % of aluminum (Al) to one of the reaction layer 21 and the reaction layer 22. Further, in the case where the amount of aluminum (Al) contained in one of the reaction layer 21 and the reaction layer 22 is about 10 atomic % to 20 atomic %, the recording sensitivity of an optical recording medium 10 becomes highest. Thus, it is most preferable to add about 20 atomic % of

aluminum (Al) to one of the reaction layer 21 and the reaction layer 22.

[0030]

Although it is preferable for one of the reaction layer 21 and the reaction layer 22 to contain substantially no element other than copper (Cu) and aluminum (Al), one of the reaction layer 21 and the reaction layer 22 may contain an element other than copper (Cu) and aluminum (Al) as impurities in an amount equal to or smaller than 1 atomic %. Therefore, in this specification, the statement "the reaction layer is made of a material substantially consisting of copper (Cu) as a primary component and aluminum (Al) as an additive" means that the reaction layer contains an element other than copper (Cu) and aluminum (Al) in an amount equal to or smaller than 1 atomic %.

[0031]

Further, in the present invention, the other of the reaction layer 21 and the reaction layer 22, preferably, the reaction layer 22, contains silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) and aluminum (Al) as a primary component. The statement "a layer contains an element as a primary element" indicates that the content of the element is largest among elements contained in the layer. In order to improve the recording sensitivity of an optical recording medium, the other of the reaction layer 21 and the reaction layer 22 may be added with magnesium (Mg) (except the case where magnesium (Mg) is contained therein as a primary component), aluminum (Al) (except the case where aluminum (Al) is contained therein as a primary component), copper (Cu), silver (Ag), gold (Au) or the like in addition to silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) or aluminum (Al) contained therein as a primary component. It is preferable for the other of the reaction

layer 21 and the reaction layer 22 to contain silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg) or aluminum (Al) as a primary component and it is most preferable for the other of the reaction layer 21 and the reaction layer 22 to contain silicon (Si).

[0032]

From the viewpoint described above, it is most preferable for the reaction layer 21 to be formed of only a material containing copper (Cu) as a primary component and about 20 atomic % of aluminum (Al) as an additive and for the reaction layer 22 to be formed of a material containing silicon (Si) as a primary component. In the case where the reaction layer 21 and the reaction layer 22 are formed of these material, it is possible to provide an optical recording medium which has a sufficiently improved storage reliability and high recording sensitivity and can be lower jitter of a reproduced signal. In addition, in the case where the reaction layer 21 and the reaction layer 22 are formed of these material, particularly high modulation can be obtained when a laser beam having a wavelength of 380 nm to 450 nm is employed for recording data in or reproducing data from an optical recording medium.

[0033]

The smoothness of the surface 22a of the reaction layer 22 irradiated with the laser beam L becomes worse as the thickness of the recording layer 14 becomes thicker. As a result, the noise level of the reproduced signal becomes higher and the recording sensitivity is lowered. Therefore, it is preferable to form the thickness of the recording layer 14 thinner in order to improve the smoothness of the surface 22a of the reaction layer 22, thereby preventing the noise level of the reproduced signal from becoming high and improving the recording sensitivity of an optical recording medium but in the case where the

thickness of the recording layer 14 is too small, the change in optical constant between before and after the recording of data is small, so that a reproduced signal having high strength (C/N ratio) cannot be obtained. Moreover, in the case where the thickness of the recording layer 14 is too small, it becomes difficult to control the thickness of the recording layer 14. Therefore, it is preferable for the thickness of the recording layer 14 to be 2 nm to 40 nm, it is more preferable for the thickness of the recording layer 14 to be 2 nm to 20 nm and it is particularly preferable for the thickness of the recording layer 14 to be 2 nm to 15 nm.

[0034]

The individual thicknesses of the reaction layer 21 and the reaction layer 22 are not particularly limited but in order to suppress the noise level of the reproduced signal to a sufficiently low level, considerably improve the recording sensitivity and greatly increase the change in optical constant between before and after the recording of data, it is preferable to set the thickness of each of the reaction layer 21 and the reaction layer 22 from 1 nm to 30 nm. Further, it is preferable to define the ratio of the thickness of the reaction layer 21 to the thickness of the reaction layer 22 (thickness of reaction layer 21 / thickness of reaction layer 22) to be from 0.2 to 5.0.

[0035]

Each of the reflective layer 12, the dielectric layer 13, the recording layer 14, namely, the reaction layer 21 and the reaction layer 22 and the dielectric layer 15 can be formed using a gas phase growth process using chemical species containing elements for forming it. Illustrative examples of the gas phase growth processes include vacuum deposition (vacuum evaporation) process, sputtering process and the like but it is preferable to use the sputtering process.

[0036]

The light transmission layer 16 constitutes a light incidence plane of the laser beam and serves to transmit a laser beam. The light transmission layer 16 preferably has a thickness of 10 μm to 300 μm. More preferably, the light transmission layer 16 has a thickness of 50 μm to 150 μm. The material used to form the light transmission layer 16 is not particularly limited insofar as it has a sufficiently high light transmittance with the respect to the wavelength of a laser beam L but an acrylic system ultraviolet ray curable resin or an epoxy system ultraviolet ray curable resin is preferably used for forming the light transmission layer 16. Instead of forming the light transmission layer of an acrylic ultraviolet ray curable resin or an epoxy ultraviolet ray curable resin, the light transmission layer 16 may be formed using a sheet made of light transmittable resin, various adhesive agents and agglutinants.

[0037]

The optical recording medium 10 having the above-described layer configuration can, for example, be fabricated in the following manner.

[0038]

Next, a principle of recording data in the optical recording medium 10 will be described below.

[0039]

When data are to be recorded in the optical recording medium 10, as shown in Figure 1, the recording layer 14 is first irradiated via the light incidence plane 16a with a laser beam L whose power is modulated. At this time, an objective lens having the numerical aperture NA equal to or larger than 0.7 and a laser beam L having a wavelength of 380 nm to 450 nm are used, for example. It is preferable to employ an objective lens

having the numerical aperture NA of about 0.85 and a laser beam having a wavelength of about 405 nm.

[0040]

When the laser beam L is projected onto the recording layer 14 of the optical recording medium 10, the recording layer 14 is heated, thereby mixing the element contained in the reaction layer 21 and the element contained in the reaction layer 22. As shown in Figure 2 (b), a recording mark M is formed by the thus formed mixed region of the recording layer 14. Since the reflection coefficient of the region of the recording layer 14 where the record mark M is thus formed is different from those of other regions of the recording layer 14, it is possible to record data in or reproduced from the optical recording medium 10. Further, in this preferred embodiment of the present invention, since the reaction layer 21 and the reaction layer 22 are formed of the above mentioned materials, it is possible to sufficiently improve the storage reliability and the recording sensitivity of the optical recording medium 10 and lower jitter of a reproduced signal. In addition, since the above mentioned materials used for forming the reaction layer 21 and the reaction layer 22 are very common in the earth, it is possible to prevent the load applied to the global environment from increasing.

[0041]

Figure 3 is a preferred example of a diagram showing pulse train patterns used for modulating the power of the laser beam L in the case of recording data in the recording layer 14 of the optical recording medium 10, where Figure 3 (a) shows a pulse train pattern used in the case of recording 2T signals, Figure 3 (b) shows a pulse train pattern used in the case of recording 3T signals, Figure 3 (c) shows a pulse train pattern used in the case of recording 4T signals and Figure 3 (d) shows a pulse

train pattern used in the case of recording one among a 5T signal to an 8T signal.

[0042]

As shown in Figures 3 (a) to 3 (d), according to these pulse train patterns, the power of the laser beam L is modulated between two levels (two values) including a recording power *Pw1* and a bottom power *Pb1* where *Pb1* is lower than *Pw1*.

[0043]

The recording power *Pw1* is set to such a high level that the reaction layer 21 and the reaction layer 22 can be melted and mixed when the laser beam L whose power is set to the recording power *Pw1* is projected onto the recording layer 14. On the other hand, the bottom power *Pb1* is set to such an extremely low level that regions of the recording layer 14 heated by irradiation with the laser beam L whose power is set to the recording power *Pw1* can be cooled by irradiation with the laser beam L whose power is set to the ground power *Pb1*.

[0044]

As shown in Figure 3 (a), in the case of recording a 2T signal in the optical recording medium 10, the number of recording pulses is set to "1". Here, the number of recording pulses is defined as how often the power of a laser beam L is increased to a recording power *Pw1* or *Pw2*. The definition of the number of recording pulses when the level of a recording power is set to *Pw2* will be described in detail later. More concretely, the power of the laser beam L is modulated so that it is set to a bottom power *Pb1* before a time t11, it is set to the recording power *Pw1* during a time period t_{top} from the time t11 to a time t12 and it is again set to the bottom power *Pb1* after the time t12.

[0045]

Further, as shown in Figure 3 (b), in the case of recording a 3T signal in the optical recording medium 10, the number of recording pulses is set to "2". Specifically, the power of the laser beam L is modulated so that it is set to the recording power *Pw1* during a time period t_{top} from a time t21 to a time t22 and a time period t_{lp} from a time t23 to a time t24 and it is set to a bottom power *Pb1* during other time periods.

[0046]

Furthermore, as shown in Figure 3 (c), in the case of recording a 4T signal in the optical recording medium 10, the number of recording pulses is set to "3". Specifically, the power of the laser beam L is modulated so that it is set to the recording power *Pw1* during a time period t_{top} from a time t31 to a time t32, a time period t_{mp} from a time t33 to a time t34 and a time period t_{lp} from a time t35 to a time t36 and it is set to a bottom power *Pb1* during other time periods.

[0047]

Moreover, as shown in Figure 3 (c), in the case of recording one among a 5T signal to an 8T signal in the optical recording medium 10 using the second pulse train pattern, the number of recording pulses is set to one of "4" to "7" so as to correspond to the length of a signal to be recorded in the optical recording medium 30. Specifically, the power of the laser beam L is modulated so that it is set to the recording power *Pw1* during a time period t_{top} from a time t41 to a time t42, a time period t_{mp} from a time t43 to a time t44, a time period t_{mp} from a time t45 to a time t46 and the like and a time period t_{lp} from a time t47 to a time t48 and it is set to a bottom power *Pb1* during other time periods.

[0048]

In this manner, in a region of the recording layer 14 where one of

a 2T signal to an 8T signal is to be recorded, the reaction layer 21 and the reaction layer 22 for constituting the recording layer 14 are melted and mixed by the irradiation with a laser beam whose power is set to the recording power *Pw1*, thereby forming a recording mark M.

[0049]

As described above, the recording layer 14 in this preferred embodiment of the present invention has features that it is a high light transmittance and that the difference in a light transmittance with respect to a laser beam L having a wavelength of 380 nm to 450 nm between a region thereof where a recording mark M is formed and other regions thereof is extremely small. Considering these features of the recording layer 14, it can be considered that the recording layer 14 in the above described preferred embodiment of the present invention is suitable for a recording layer of an optical recording medium including a plurality of laminated information recording layers. Thus, another preferred embodiment of the present invention in which the present invention is applied to an optical recording medium including a plurality of laminated information recording layers will be described below.

[0050]

Figure 4 is a partially cross-sectional view showing an optical recording medium 30 that is another preferred embodiment of the present invention. Similarly to the optical recording medium 10 shown in Figure 1, the optical recording medium 30 is formed disk-like and has an outer diameter of about 120 mm and a thickness of about 1.2 mm. Figure 4 shows an enlarged schematic cross-sectional view of the part of the optical recording medium indicated by A in Figure 1 (a).

[0051]

As shown in Figure 4, the optical recording medium 30 according

to this preferred embodiment of the present invention includes a support substrate 31, a transparent intermediate layer 32, a light transmission layer 33, an information recording layer L0 formed between the support substrate 31 and the transparent intermediate layer 32, and an information recording layer L1 formed between the transparent intermediate layer 32 and the light transmission layer 33. The information recording layer L0 constitutes an information recording layer far from a light incidence plane 33a and the information recording layer L1 constitutes an information recording layer close to the light incidence plane 33a. In this manner, the optical recording medium 30 according to this preferred embodiment of the present invention includes two laminated information recording layer.

[0052]

In the thus constituted optical recording medium 30, when data are to be recorded in or reproduced from the information recording layer L0, a laser beam L is projected onto the information recording layer L0 via the information recording layer L1. Therefore, it is necessary for the information recording layer L1 to have a sufficiently high light transmittance. Concretely, it is preferable for the information recording layer L1 to have a light transmittance equal to or higher than 40 % with respect to the wavelength of a laser beam L used for recording data in or reproduced from the optical recording medium 30 and it is more preferable for the information recording layer L1 to have a light transmittance equal to or higher than 50 %.

[0053]

The support substrate 31 is a member corresponding to the support substrate 11 of the optical recording medium shown in Figure 1 and formed of a similar material to that of the support substrate 11 of the

optical recording medium shown in Figure 1 so as to have a similar thickness to that of the support substrate 11. Grooves 31a and lands 31b are formed on the surface of the support substrate 31 and the grooves 31a and the lands 31b serve as a guide track for the laser beam L when data are to be recorded in or data are to be reproduced from the information recording layer L0.

[0054]

The transparent intermediate layer 32 serves to space the information recording layer L0 and the information recording layer L1 apart by a physically and optically sufficient distance and grooves 32a and lands 32b are formed on the surface of the transparent intermediate layer 32. The grooves 32a and the lands 32b serve as a guide track for the laser beam L when data are to be recorded in or data are to be reproduced from the information recording layer L1. The material for forming the transparent intermediate layer 32 is not particularly limited and an ultraviolet ray curable acrylic resin is preferably used for forming the transparent intermediate layer 32. It is necessary for the transparent intermediate layer 32 to have sufficiently high light transmittance since the laser beam L passes through the transparent intermediate layer 32 when data are to be recorded in the information recording layer L0 and data recorded in the information recording layer L0 are to be reproduced.

[0055]

The light transmission layer 33 is a member corresponding to the light transmission layer 16 of the optical recording medium shown in Figure 1 and formed of a similar material to that of the light transmission layer 16 of the optical recording medium shown in Figure 1 so as to have a similar thickness to that of the light transmission layer 16.

[0056]

The information recording layer L1 has a layer configuration obtained by omitting the reflective layer 12 from the layers provided between the support substrate 11 and the light transmission layer 16 of the optical recording medium shown in Figure 1. Specifically, the information recording layer L1 is constituted by the recording layer 14 including the reaction layer 21 and the reaction layer 22 and the dielectric layers 13, 15 formed so as to sandwich the recording layer 14 therebetween. Similarly to the optical recording medium according to the previous preferred embodiment of the present invention, as shown in Figure 5 (a), the reaction layer 21 and the reaction layer 22 are laminated at an unrecorded region of the recording layer 14. When the recording layer 14 is irradiated with a laser beam having a predetermined power or more, the element contained in the reaction layer 21 as a primary component and the element contained in the reaction layer 22 as a primary component partially or totally diffuse by heat generated by the laser beam to mix with each other, whereby a recording mark M is formed, as shown in Figure 5 (b). Thus, desired data can be recorded in the information recording layer L1 of the optical recording medium 30. Here, a very thin reflective layer 12 may be provided in the information recording layer L1 insofar as the desired light transmittance of the information recording layer L1 can be ensured.

[0057]

The dielectric layers 13 and 15 can be formed of the same materials as those used in the previous preferred embodiment of the present invention and the reaction layer 21 and the reaction layer 22 can be formed of the same materials as those used in the previous preferred embodiment. Specifically, one of the reaction layer 21 and the reaction

layer 22, preferably, the reaction layer 21, is formed of the material containing copper (Cu) as a primary component and 10 atomic % to 30 atomic % of aluminum (Al) as an additive and the other of the reaction layer 21 and the reaction layer 22, preferably, the reaction layer 22, is formed of the material containing silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) or aluminum (Al) as a primary component. Therefore, the information recording layer L1 has high recording sensitivity and jitter of a signal obtained by reproducing data recorded in the information recording layer L1 can be sufficiently lowered. Further, the information recording layer L1 also has a high storage reliability.

[0058]

In addition, since the information recording layer L1 can be formed by forming the recording layer 14 of the above described materials so as to have high light transmittance equal to or higher than 50 %, for example, data can be recorded in information recording layer L0 with high sensitivity.

[0059]

Further, since the recording layer 14 is formed of the above described materials, the difference in a light transmittance with respect to a laser beam having a wavelength of 380 nm to 450 nm between a region of the information recording layer L1 where the reaction layer 21 and the reaction layer 22 are laminated, namely a region of the information recording layer L1 where no recording mark M is formed, and a region of the information recording layer L1 where the reaction layer 21 and the reaction layer 22 are mixed, namely, a region of the information recording layer L1 where a recording mark M is formed is extremely small. Specifically, in the case where a laser beam L having a

wavelength of 380 nm to 450 nm is employed, the difference in a light transmittance between the region of the information recording layer L1 where the reaction layer 21 and the reaction layer 22 are laminated and the region of the information recording layer L1 where the reaction layer 21 and the reaction layer 22 are mixed can be made 3 % or less and in particular, the difference in a light transmittance with respect of a laser beam having a wavelength of about 405 nm used for a next-generation type optical recording medium between the region of the information recording layer L1 where the reaction layer 21 and the reaction layer 22 are laminated and the region of the information recording layer L1 where the reaction layer 21 and the reaction layer 22 are mixed can be made 1 % or less. Therefore, when data are to be recorded in or reproduced from the information recording layer L0, since the amount of the laser beam L projected onto the L0 information recording layer 50 hardly changes depending upon whether the spot of the laser beam L is formed on unrecorded regions of the information recording layer L1 where no recording mark M is formed or regions of the information recording layer L1 where a plurality of recording marks M are formed and further whether the spot of the laser beam L is formed in a region of the information recording layer L1 including the boundary between the unrecorded region of the information recording layer L1 where no recording mark M is formed and the region of the information recording layer L1 where a recording marks M is formed or the spot of the laser beam L is formed in a region of the information recording layer L1 including no boundary, it is possible to record data in or reproduce data from the information recording layer L0 in a stable manner.

[0060]

Here, the layer configuration of the information recording layer

L0 is not particularly limited but the information recording layer L0 can be formed so as to have a similar layer configuration to that of layers between the support substrate 11 and the light transmission layer 16 of the optical recording medium 10 according to the previous preferred embodiment of the present invention (See Figure 2). Further, it is not absolutely necessary for the information recording layer L0 to be constituted as a write-once type information recording layer and the information recording layer L0 may be constituted so as to enable only data reading without forming a recording layer. In such a case, prepits are formed on the support substrate 31 and information is carried by the prepits in the information recording layer L0.

[0061]

Figure 6 is a preferred example of a diagram showing pulse train patterns used for modulating the power of the laser beam L when data are to be recorded in the information recording layer L1 of the optical recording medium 30, where Figure 6 (a) shows a pulse train pattern used in the case of recording 2T signals, Figure 6 (b) shows a pulse train pattern used in the case of recording 3T signals, Figure 6 (c) shows a pulse train pattern used in the case of recording 4T signals and Figure 6 (d) shows a pulse train pattern used in the case of recording one among a 5T signal to an 8T signal.

[0062]

As shown in Figures 6 (a) to 3 (d), according to these pulse train patterns, the power of the laser beam L is modulated between three levels (three values) including a recording power *Pw2*, an intermediate power *Pm2* and a bottom power *Pb2*.

[0063]

The levels of the recording power *Pw2*, the intermediate power

Pm2 and the bottom power *Pb2* are determined so that *Pw2* is higher than *Pm2* and *Pm2* is higher than *Pb2*. The recording power *Pw2* is set to such a high level that the reaction layer 21 and the reaction layer 22 can be melted and mixed when the laser beam L whose power is set to the recording power *Pw2* is projected onto the recording layer 14. On the other hand, each of the intermediate power *Pm2* and the bottom power *Pb2* is set to such a low level that the reaction layer 21 and the reaction layer 22 cannot be melted and mixed when the laser beam L whose power is set to the intermediate power *Pm2* or the bottom power *Pb2* is projected onto the recording layer 14. In particular, the bottom power *Pb1* is set to such an extremely low level that the reaction layer 21 and the reaction layer 22 are hardly heated even when the laser beam L whose power is set to the bottom power *Pb2* is projected onto the recording layer 14 and that regions of the recording layer 14 heated by irradiation with the laser beam L whose power is set to the recording power *Pw2* can be cooled by irradiation with the laser beam L whose power is set to the ground power *Pb2*.

[0064]

As shown in Figure 6 (a), in the case of recording a 2T signal in the optical recording medium 30, the number of recording pulses is set to "1" and a cooling time period t_{cl} is inserted into the pulse train pattern after the recording pulse. More concretely, the power of the laser beam L is modulated so that it is set to an intermediate power *Pm2* until a time t51, it is set to the recording power *Pw2* during a time period t_{top} from the time t51 to a time t52, it is set to a bottom power *Pb2* during a cooling time period t_{cl} from the time t52 to a time t53 and it is again set to the intermediate power *Pm2* after the time t53.

[0065]

Further, as shown in Figure 6 (b), in the case of recording a 3T signal in the optical recording medium 30, the number of recording pulses is set to "2" and a cooling time period t_{cl} is inserted into the pulse train pattern after the recording pulse. More specifically, the power of the laser beam L is modulated so that it is set to an intermediate power $Pm2$ until a time t61, it is set to the recording power $Pw2$ during a time period t_{top} from the time t61 to a time t62 and a time period t_{lp} from a time t63 to a time t64, it is set to a bottom power $Pb2$ during a time period t_{off} from the time t62 to a time t63 and a cooling time period t_{cl} from a time t64 to a time t65, and it is again set to the intermediate power $Pm2$ after the time t65.

[0066]

Furthermore, as shown in Figure 6 (c), in the case of recording a 4T signal in the optical recording medium 30, the number of recording pulses is set to "3" and a cooling time period t_{cl} is inserted into the pulse train pattern after the recording pulse. More specifically, the power of the laser beam L is modulated so that it is set to an intermediate power $Pm2$ until a time t71, it is set to the recording power $Pw2$ during a time period t_{top} from the time t71 to a time t72, a time period t_{mp} from a time t73 to a time t74 and a time period t_{lp} from a time t75 to a time t76, it is set to a bottom power $Pb2$ during a time period t_{off} from the time t72 to a time t73, a time period t_{off} from the time t74 to the time t75 and a cooling time period t_{cl} from the time t76 to a time t77, and it is again set to the intermediate power $Pm2$ after the time t77.

[0067]

Moreover, as shown in Figure 6 (d), in the case of recording one among a 5T signal to an 8T signal in the optical recording medium 30, the number of recording pulses is set to one of "4" to "7" so as to

correspond to the length of a signal to be recorded in the optical recording medium 30 and a cooling time period t_{cl} is inserted into the pulse train pattern after the recording pulse. Therefore, the number of multi-pulses is set to one of "5" to "8" so as to correspond to the length of a signal to be recorded in the optical recording medium 30 among a 5T signal to an 8T signal. More specifically, the power of the laser beam L is modulated so that it is set to the recording power *Pw2* during a time period t_{top} from a time t81 to a time t82, a time period t_{mp} from a time t83 to a time t84, a time period t_{mp} from a time t85 to a time t86 and the like and a time period t_{lp} from a time t87 to a time t88, it is set to the bottom power *Pb2* during a time period t_{off} from the time t82 to the time t83, a time period t_{off} from the time t86 to the time t87 and the like and a cooling time period t_{cl} from a time t88 to a time t89, and it is set to the intermediate power *Pm2* during other time periods.

[0068]

In this manner, in a region of the recording layer 14 where one of a 2T signal to an 8T signal is to be recorded, the reaction layer 21 and the reaction layer 22 for constituting the recording layer 14 are melted and mixed by the irradiation with a laser beam whose power is set to the recording power *Pw2*, thereby forming a recording mark M having a predetermined length.

[0069]

The pulse train patterns shown in Figure 6 are preferably employed in the case where data are to be recorded in the information recording layer L1 in the following reasons.

[0070]

As described above, since the information recording layer L1 is provided with no reflective layer or a very thin reflective layer, heat

radiation effects caused by the presence of the reflective layer cannot be obtained or can be hardly obtained. Therefore, in the case where the pulse train patterns shown in Figure 3 are employed for modulating the power of a laser beam L, heat generated by the irradiation with a laser beam cannot be sufficiently dissipated from the information recording layer L1, whereby there arises a risk of characteristics of a signal becoming worse. To the contrary, in the case where the pulse train patterns shown in Figure 6 are employed for modulating the power of a laser beam L to be projected onto the information recording layer L1, since the power of the laser beam is set to the bottom power *Pb2* immediately after the recording pulse, it is possible to prevent an excessive amount of heat from being accumulated in the information recording layer L1 and as a result, it is possible to obtain a signal having good signal characteristics.

[0071]

The present invention has thus been shown and described with reference to specific embodiments. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modifications may be made without departing from the scope of the appended claims.

[0072]

For example, in the above described preferred embodiments of the present invention, although each of the optical recording media 10 and 30 is constituted as a next-generation type optical recording medium constituted so that a laser beam is projected onto a recording layer via a very thin light transmission layer, an optical recording medium to which the present invention is applied is not limited to such a next-generation type optical recording medium and the present invention can be applied

to a DVD type optical recording medium and a CD type optical recording medium.

[0073]

Further, in the optical recording media 10 and 30 described in the above described preferred embodiments of the present invention, although the recording layer 14 is constituted by only the two reaction layers 21 and 22, the recording layer may include a third reaction layer and a dielectric layer.

[0074]

Furthermore, although the optical recording medium 30 includes the two laminated information recording layers L0 and L1, an optical recording medium to which the present invention is applied may include three or more laminated information recording layers L0, L1, L2 and so on. In such a case, if the information recording layer disposed closest to the light incidence plane is formed so as to have the above described layer configuration, it is possible to record data in or reproduced from the information recording layers other than the information recording layer disposed closest to the light incidence plane in a stable manner.

[0075]

[WORKING EXAMPLES]

Hereinafter, working examples will be set out in order to further describe the present invention concretely. However, the present invention is in no way limited to the working examples.

[0076]

[Preparation of Optical Recording Medium Samples]

An optical recording medium sample having a layer configuration obtained by omitting the reflective layer 12 from that of the optical recording medium 10 shown in Figure 1 and 2 in the following manner.

[0077]

A disk-like support substrate 11 made of polycarbonate, having a thickness of 1.1 mm and a diameter of 120 mm and formed with grooves 11a and lands 11b on the surface thereof was first fabricated by an injection molding.

[0078]

Then, the support substrate 11 was set on a sputtering apparatus and a dielectric layer 13 consisting of a mixture of ZnS and SiO_2 whose mole ratio was 80:20 and having a thickness of 25 nm, a reaction layer 21 consisting of a material containing copper (Cu) as a primary component and 10 atomic % of aluminum (Al) as an additive and having a thickness of 5 nm, a reaction layer 22 containing Si as a primary component and having a thickness of 4 nm and a dielectric layer 15 consisting of TiO_2 were sequentially formed on the surface of the support substrate 11 on which the grooves 11a and lands 11b were formed, using the sputtering process. The amount of aluminum (Al) added to the reaction layer 21 was varied and the thickness of the dielectric layer 15 was optimized depending upon the amount of aluminum (Al) added to the reaction layer 21 within a range from 30 nm to 33 nm.

[0079]

Next, the dielectric layer 15 was coated with acrylic system ultraviolet ray curable resin using a spin coating process to form a coating layer and the coating layer was irradiated with an ultraviolet ray to be cured, thereby forming a light transmission layer 16 having a thickness of 100 μm. Thus, the optical recording medium sample was fabricated. The thus fabricated optical recording medium sample can be considered to have a layer configuration obtained by omitting the information recording layer L0 from that of the optical recording medium

30 shown in Figures 4 and 5, in other words, include only the information recording layer L1.

[0080]

[Evaluation of Optical Recording Medium Sample]

The thus fabricated optical recording medium sample was set in an optical recording medium evaluation apparatus "DDU1000" (Product Name) manufactured by Pulstec Industrial Co., Ltd. and a laser beam which has a wavelength of 405 nm and whose power was modulated using a pulse train pattern shown in Figure 6 was focused onto the recording layer 14, namely, the reaction layer 21 and the reaction layer 22 using an objective lens whose numerical aperture was 0.85 while the optical recording medium sample was rotated at a linear velocity of 5.3 m/sec, thereby recording random signals including 2T signals to 8T signals therein. The pulse widths of the pulse train pattern were set so that t_{top} was equal to 0.5T, t_{mp} and t_{lp} were equal to 0.4T and t_{cl} was equal to 1.2T. The recording power *Pw2* was varied while the intermediate power *Pm2* was fixed to 2.4 mW and the bottom power *Pb2* was fixed to 0.1 mW.

[0081]

Next, the random signals recorded in the optical recording medium sample using different recording powers *Pw2* of the laser beam were reproduced and jitter of each of the reproduced signal was measured. Then, the lowest jitter was determined from among the thus measured jitters and the recording power *Pw2* at which the jitter of the reproduced signal was lowest was determined as an optimum recording power *Pw2* of the laser beam. Here, jitter corresponded to clock jitter and the fluctuation σ of a reproduced signal was measured using a time interval analyzer and the clock jitter was calculated as σ/Tw, where Tw

was one clock period.

[0082]

Further, a step of fabricating an optical recording medium sample, recording random signals therein, reproducing the random signal therefrom and measuring jitter of the reproduced signal was repeated in a similar manner to the above and the dependency of the recording sensitivity of each of the optical recording medium samples and jitter of a signal reproduced from each of the optical recording medium samples on the amount of aluminum (Al) added to the reaction layer 21 thereof was measured. The results of measurement are shown in Figure 7.

[0083]

As shown in Figure 7, it was found that in the case where the amount of aluminum (Al) added to the reaction layer 21 was 10 atomic % to 30 atomic %, jitter of the reproduced signal was equal to or lower than 6 %, i.e., jitter could be sufficiently reduced, and it was further found that in the case where the amount of aluminum (Al) added to the reaction layer 21 was 20 atomic % to 25 atomic %, jitter of the reproduced signal could be markedly reduced. Moreover, as shown in Figure 7, it was found that in the case where the amount of aluminum (Al) added to the reaction layer 21 was equal to or less than 25 atomic %, the optimum recording power $Pw2$ of the laser beam was equal to or lower than 8.5 mW and that in the case where the amount of aluminum (Al) added to the reaction layer 21 was 10 atomic % to 20 atomic %, the optimum recording power $Pw2$ of the laser beam was equal to or lower than 8.0 mW. On the other hand, it was found that in the case where the amount of aluminum (Al) added to the reaction layer 21 was equal to or larger than 40 atomic %, the recording sensitivity was improved but the jitter characteristics were not sufficiently improved.

[0084]

Next, each of the optical recording medium samples was irradiated with a laser beam having a wavelength of 405 nm and the light transmittance thereof was measured. The results of the measurement are shown in Figure 8.

[0085]

As shown in Figure 8, it was found that the optical recording samples in which the amount of aluminum (Al) added to the reaction layer 21 was 10 atomic % to 30 atomic % had light transmittances equal to or higher than 50. Thus, it was confirmed that each of these optical recording medium samples has a layer configuration suitable for being used as the information recording layer L1 of the optical recording medium 30 shown in Figures 4 and 5.

[0086]

[TECHNICAL ADVANTAGE OF THE INVENTION]

As described above, according to the present invention, it is possible to provide a write-once type optical recording medium whose recording layer is formed by laminating a plurality of reaction layers each containing an inorganic material and which can simultaneously improve the jitter characteristics of a signal reproduced the optical recording medium and the recording sensitivity of the optical recording medium. In addition, since the recording layer included in the write-once type optical recording medium having a such a layer configuration has high light transmittance, in the case where a write-once type optical recording medium having a plurality of information recording layers is constituted so as to include the recording layer in an information recording layer closer to a light incidence plane, it is possible to improve the data recording and reproducing characteristics of the write-once type

optical recording medium when data are to be recorded in or reproduced from an information recording layer farther to the light incidence plane in a desired manner.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Figure 1]

Figure 1 (a) is a schematic partially cut-out perspective view showing an external appearance of an optical recording medium 10 that is a preferred embodiment of the present invention and Figure 1 (b) is an enlarged schematic cross-sectional view of the part of the optical recording medium indicated by A in Figure 1 (a).

[Figure 2]

Figure 2 is an enlarged cross sectional view schematically showing a main portion of the optical recording medium 10 shown in Figure 1, where Figure 2 (a) schematically showing a region of the optical recording medium 10 where no data are recorded and Figure 2 (b) is an enlarged cross sectional view schematically showing a region of the optical recording medium 10 where a recording mark M is formed.

[Figure 3]

Figure 3 is a preferred example of a diagram showing pulse train patterns used for modulating the power of the laser beam L in the case of recording data in the optical recording medium 10, where Figure 3 (a) shows a pulse train pattern used in the case of recording 2T signals, Figure 3 (b) shows a pulse train pattern used in the case of recording 3T signals, Figure 3 (c) shows a pulse train pattern used in the case of recording 4T signals and Figure 3 (d) shows a pulse train pattern used in the case of recording one among a 5T signal to an 8T signal.

[Figure 4]

Figure 4 is a schematic partially cross-sectional view showing an optical recording medium 30 that is another preferred embodiment of the present invention.

[Figure 5]

Figure 5 is an enlarged cross sectional view schematically showing a main portion of an information recording layer L1 of the optical recording medium 30 shown in Figure 4, where Figure 5 (a) schematically showing a region of the information recording layer L1 where no data are recorded and Figure 5 (b) is an enlarged cross sectional view schematically showing a region of the information recording layer L1 where a recording mark M is formed.

[Figure 6]

Figure 6 is a preferred example of a diagram showing pulse train patterns used for modulating the power of the laser beam L when data are to be recorded in the information recording layer L1 of the optical recording medium 30, where Figure 6 (a) shows a pulse train pattern used in the case of recording 2T signals, Figure 6 (b) shows a pulse train pattern used in the case of recording 3T signals, Figure 6 (c) shows a pulse train pattern used in the case of recording 4T signals and Figure 6 (d) shows a pulse train pattern used in the case of recording one among a 5T signal to an 8T signal.

[Figure 7]

Figure 7 is a graph showing the dependency of the recording sensitivity of each of the optical recording medium samples and jitter of a signal reproduced from each of the optical recording medium samples on the amount of aluminum (Al) added to the reaction layer 21 thereof.

[Figure 8]

Figure 8 is a graph showing the relationship between the amount

of aluminum (Al) added to the reaction layer 21 of each of the optical recording medium samples and light transmittance of each of the optical recording medium samples.

[BRIEF DESCRIPTION OF REFERENCE NUMERALS]

10, 30 ..... an optical recording medium

11, 31 ..... a substrate

11a, 31a, 32a ..... a groove

11b, 31b, 32b ..... a land

12 ..... a reflective layer

13, 15 ..... a dielectric layer

14 ..... a recording layer

16, 33 ..... a light transmission layer

16a, 33a ..... a light incidence plane

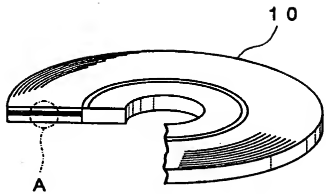
21, 22 ..... a reaction layer

32 ..... a transparent intermediate layer

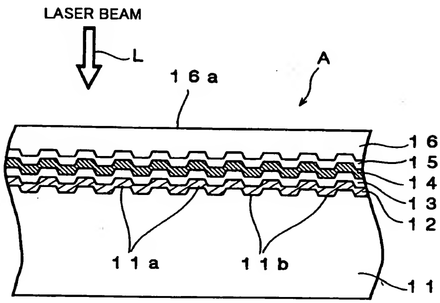
L ..... a laser beam

L0, L1 ..... an information recording layer

FIG. 1



(a)



(b)

FIG. 2

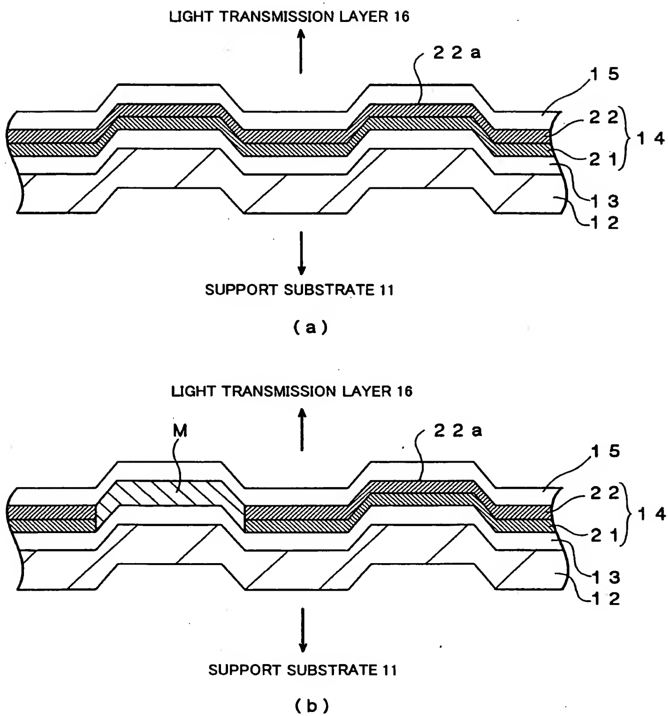
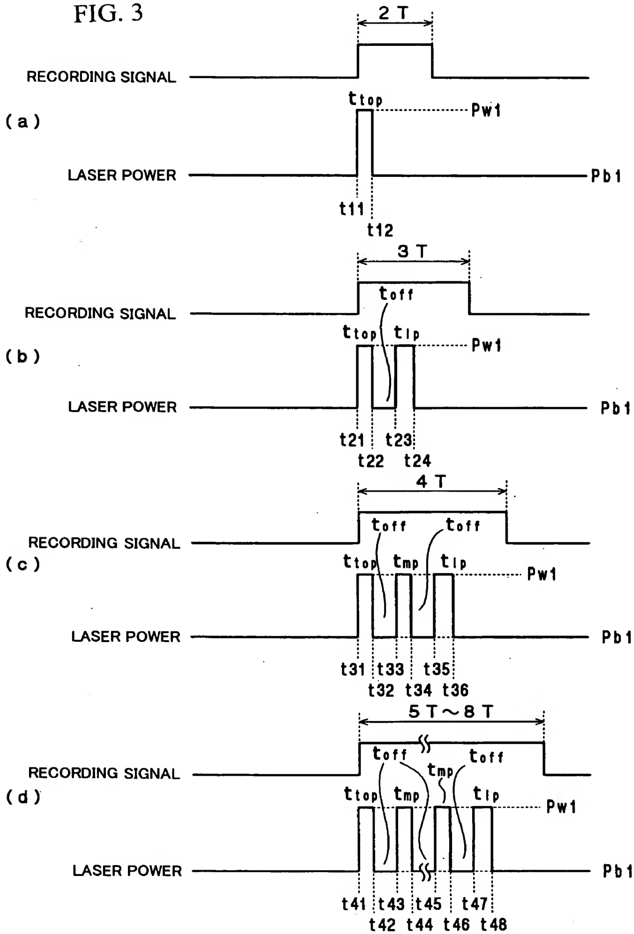

LIGHT TRANSMISSION LAYER 16
22a
15
22
14
21
13
12
SUPPORT SUBSTRATE 11
(a)
LIGHT TRANSMISSION LAYER 16
M
22a
15
22
14
21
13
12
SUPPORT SUBSTRATE 11
(b)

FIG. 3



2 T
RECORDING SIGNAL
(a)
ttop
Pw1
LASER POWER
Pb1
t11
t12
3 T
RECORDING SIGNAL
toff
(b)
ttop
tlp
Pw1
LASER POWER
Pb1
t21
t23
t22
t24
4 T
RECORDING SIGNAL
toff
toff
(c)
ttop
tmp
tlp
Pw1
LASER POWER
Pb1
t31
t33
t35
t32
t34
t36
5 T～8 T
RECORDING SIGNAL
toff
tmp
toff
(d)
ttop
tmp
tlp
Pw1
LASER POWER
Pb1
t41
t43
t45
t47
t42
t44
t46
t48

FIG. 4

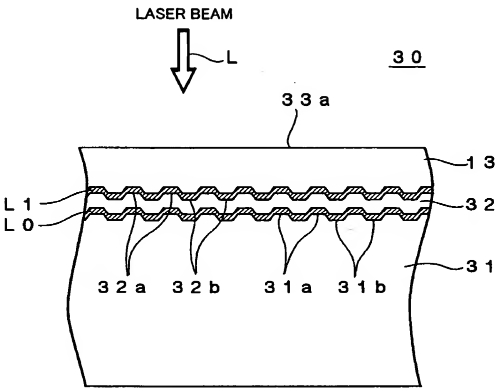
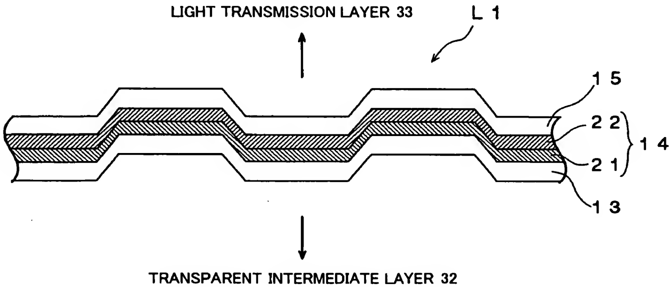
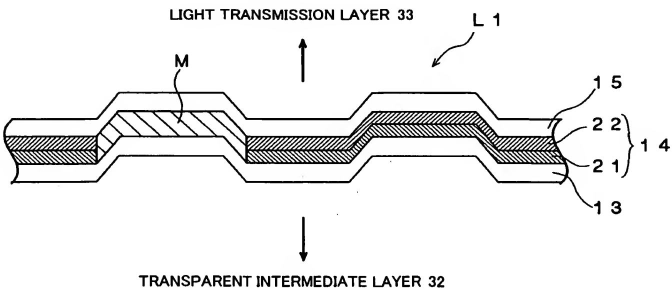


FIG. 5



LIGHT TRANSMISSION LAYER 33
L 1
1 5
2 2
1 4
2 1
1 3
TRANSPARENT INTERMEDIATE LAYER 32

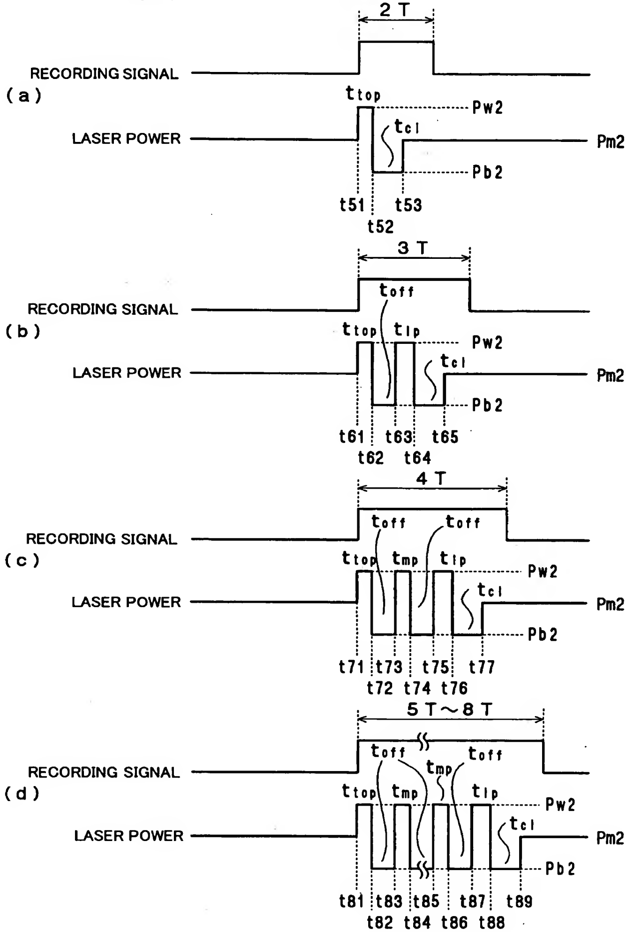
(a)



LIGHT TRANSMISSION LAYER 33
L 1
M
1 5
2 2
1 4
2 1
1 3
TRANSPARENT INTERMEDIATE LAYER 32

(b)

FIG. 6



2 T
RECORDING SIGNAL
(a)
ttop
Pw2
LASER POWER
tcl
Pm2
Pb2
t51
t53
t52
3 T
RECORDING SIGNAL
toff
(b)
ttop
tlp
Pw2
LASER POWER
tcl
Pm2
Pb2
t61
t63
t65
t62
t64
4 T
RECORDING SIGNAL
toff
toff
(c)
ttop
tmp
tlp
Pw2
LASER POWER
tcl
Pm2
Pb2
t71
t73
t75
t77
t72
t74
t76
5 T～8 T
RECORDING SIGNAL
toff
toff
tmp
(d)
ttop
tmp
tlp
Pw2
LASER POWER
tcl
Pm2
Pb2
t81
t83
t85
t87
t89
t82
t84
t86
t88

FIG. 7

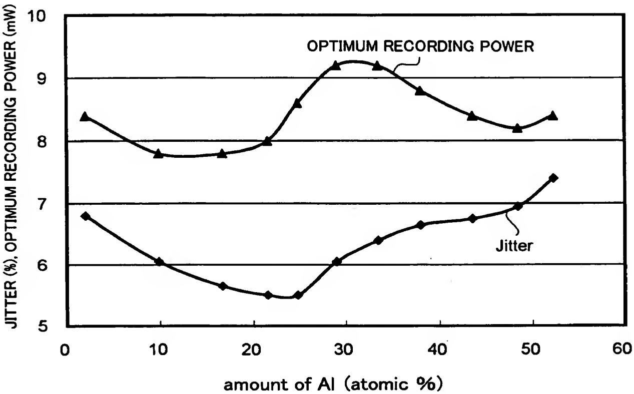
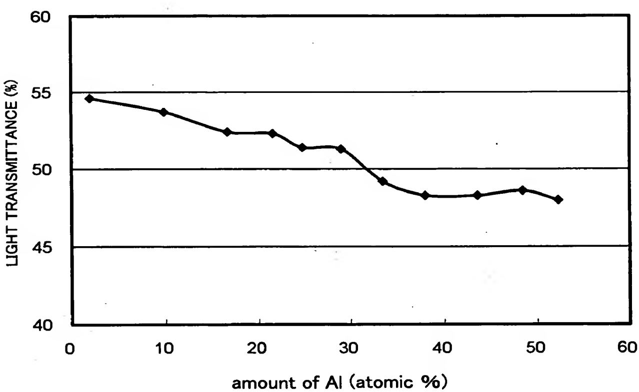

OPTIMUM RECORDING POWER
Jitter
JITTER (%), OPTIMUM RECORDING POWER (mW)
10
9
8
7
6
5
0
10
20
30
40
50
60
amount of Al (atomic %)

FIG. 8


LIGHT TRANSMITTANCE (%)
60
55
50
45
40
0
10
20
30
40
50
60
amount of Al (atomic %)

[Name of Document] ABSTRACT

[Abstract]

[Problems]

It is an object of the present invention to provide an optical recording medium whose recording layer is formed by laminating at least two reaction layers and in which the jitter characteristics of a signal reproduced from the optical recording medium and the recording sensitivity of the optical recording medium can be simultaneously improved.

[Solution]

An optical recording medium includes a support substrate 11 and a recording layer 14 provided over the support substrate 11. The recording layer 14 includes a reaction layer 21 formed of a material containing copper (Cu) as a primary component and 10 atomic % to 30 atomic % of aluminum (Al) as an additive and a reaction layer 22 formed of a material containing an element selected from the group consisting of silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), indium (In), zinc (Zn), bismuth (Bi) and aluminum (Al) as a primary component. In the case where the optical recording medium is constituted so as to include the recording layer 14 having such a layer configuration, it is possible to improve the storage reliability of the optical recording medium and simultaneously improve the jitter characteristics of a signal reproduced from the optical recording medium and the recording sensitivity of the optical recording medium.

[Selected Figure] Figure 1